

# Framework for Assessing Coalition C4 Interoperability

Fred Ma, Debbie Blakeney

Centre for Operational Research & Analysis

Defence R&D Canada

17th ICCRTS

Fairfax VA

19-21 June 2012



# Outline

- Motivation & vision for coalition interoperability assessment framework
- Challenges, scope, development process, background
- Interoperability factors, organizational structure
- Quantification & rollup of interoperability factors
- Analytical usage
- Summary

# The need for an interoperability framework

- Nations can spend a lot on interoperability activities
  - Hard to determine effectiveness
- The harder impediments are often not technical  
*Concepts, doctrine, procedures, trust, skills/training, legal, policy, command/authority structures, culture, alignment with national capability delivery & acquisition*
- Much of the above pertaining to info sharing

# Early vision of visualization dashboard

| Interoperability factor | Overall | N1     | N2     | N3     | N4     | N5     |
|-------------------------|---------|--------|--------|--------|--------|--------|
| <b>Factor 1</b>         | Yellow  | Yellow | Green  | Red    | Yellow | Yellow |
| Factor 1.1              | Yellow  | Yellow | Yellow | Yellow | Red    | Yellow |
| Factor 1.2              | Red     | Red    | Green  | Red    | Red    | Yellow |
| Factor 1.2.1            | Red     | Red    | Green  | Red    | Red    | Yellow |
| Factor 1.2.2            | Yellow  | Red    | Green  | Yellow | White  | Yellow |
| Factor 1.3              | Yellow  | Yellow | Yellow | Green  | Yellow | Yellow |
| <b>Factor 2</b>         | Yellow  | Yellow | Yellow | Red    | Yellow | Yellow |
| <b>Factor 3</b>         | Green   | Green  | Green  | Red    | Green  | Yellow |
| <b>Factor 4</b>         | Green   | Green  | Green  | Green  | Red    | Yellow |

# Challenges & restrictions

- Lack of knowledge of how the individual nations' commands work
- Unconstrained breadth
  - INT, CIS, conduct of ops (C2), in-theatre & external to theatre, national procurement systems, tactical/operational/strategic*
- Many disparate knowledge domains
- Multinational nature increases the challenge of knowledge gathering & consensus

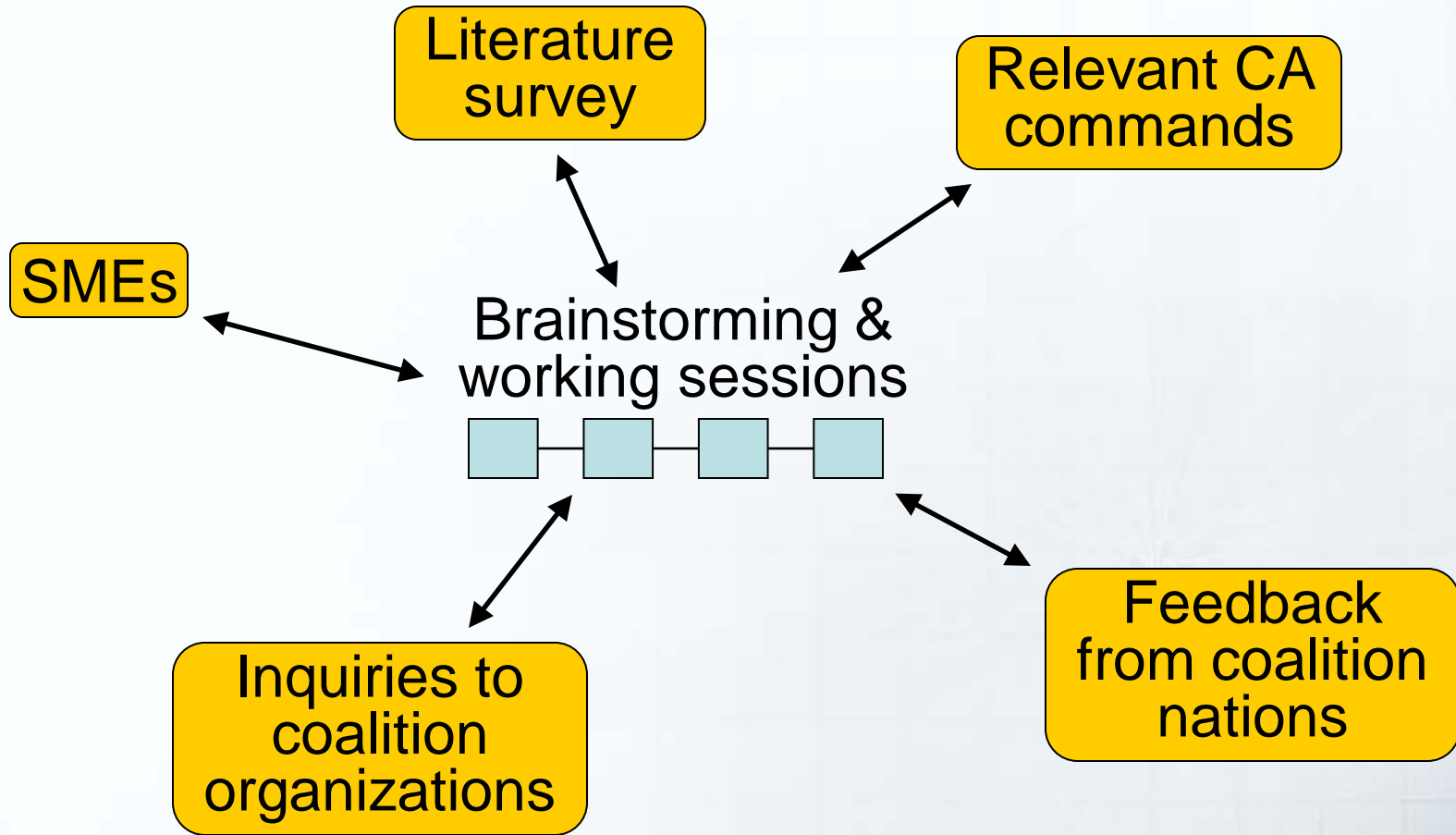
# Scope

- Technical and nontechnical interoperability factors
- Joint C4
- Strategic/operational level, external to theatre
- Strategic planning rather than INT
- ★ Perspective of operational staff rather than domain experts e.g. IT/IM
  - Heads of J1, J2, etc. or closest equivalent (LCol)
- Coalition with similar culture, shared language & heritage

# Inputs to the framework development

- Military & framework experience in framework team
- Contacts & subject matter experts directly accessible by framework team
- Contracted review of the literature on interoperability frameworks and assessment methodologies

# Framework development process





# Interoperability framework background

Largely based on Ford's 2007/9 survey

|           |        |   |
|-----------|--------|---|
| SoIM      | 1980   | Spectrum of interoperability  |
| QoIM      | 1989   | Quantification of Interoperability                                  |
| MCISI     | 1996   | Military Communications & Information Systems Interoperability      |
| LISI      | 1998   | Levels of Information Systems Interoperability                      |
| IAM       | 1998   | Interoperability Assessment   |
| OIM       | 1999   | Organisational Interoperability Maturity Model for C2               |
| NMI       | 2003   | NATO C3 Technical Architecture Reference Model for Interoperability |
| LCI       | 2003   | Interoperability Roadmap for C4ISR Legacy Systems                   |
| LCIM      | 2003   | Levels of Conceptual Interoperability Model                         |
| SoSI      | 2004   | System of Systems   |
| NTI       | 2004   | Non-technical Interoperability                                      |
| OIAM      | 2005   | Organisational Interoperability Agility Model                       |
| NCW       | 2003   | Network Centric Warfare   |
| NID       | 2005   | NATO (C3 System) Interoperability Directive                         |
| Stoplight | 2002   | Stoplight   |
| i-Score   | 2007/8 | Interoperability Score  |

# Hierarchy of interoperability factors

# Four major “Aspects”

- **Technical**

Interoperability of technology and technical systems

- **Human**

Interpersonal/international relationships and trust

- **Organization**

Institutional-based factors

- **Policy/Legal**

Legal and authority related factors, including policies, directives, procedures, and practices

# Hierarchy of interoperability factors

## Tiers T1, T2, T3

**Technical  
T1 factor**

**Human  
T1 factor**

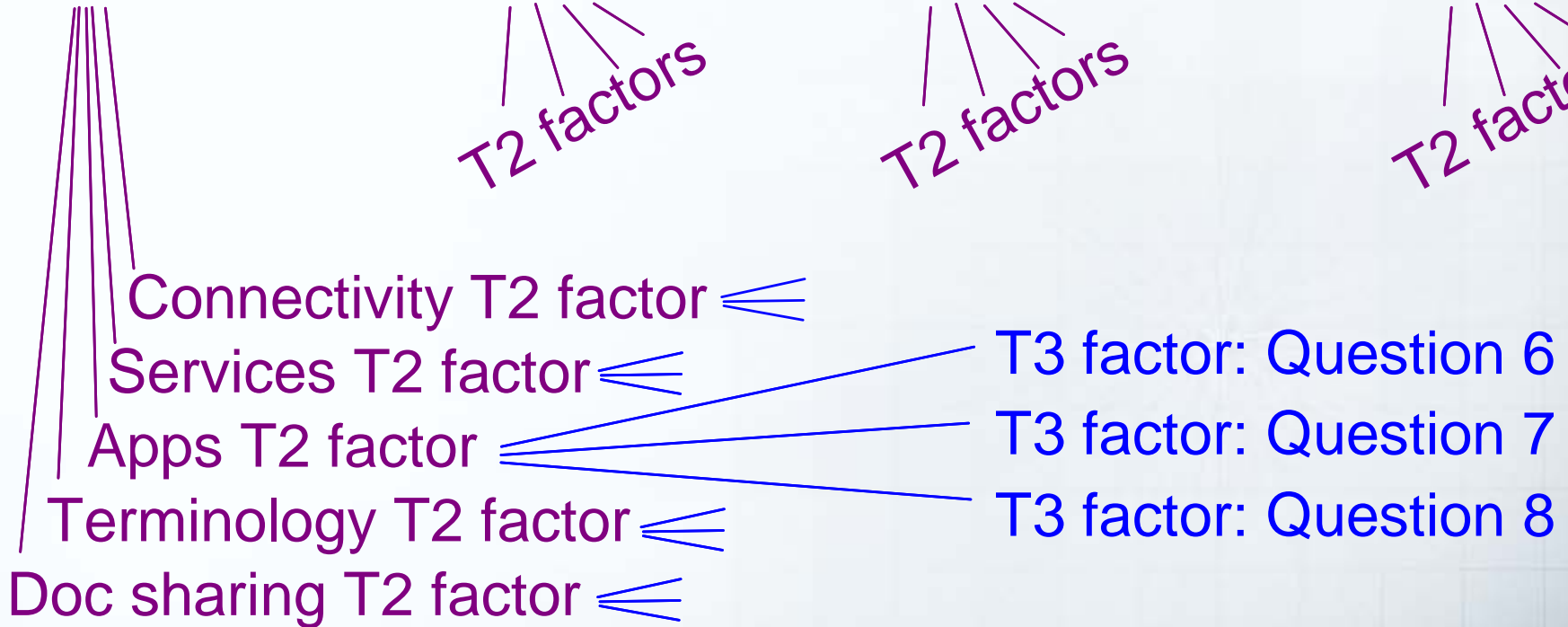
**Organizational  
T1 factor**

**Policy/Legal  
T1 factor**

T2 factors

T2 factors

T2 factors



# T2 “Themes”

|                             |   | T1 Interoperability Factors  |  |   |              |
|-----------------------------|---|--|--|---|--------------|
|                             |   | Technical  | Human  | Organizational  | Policy/Legal |
| T2 Interoperability Factors | <ul style="list-style-type: none"> <li>• International connectivity</li> <li>• Multinational services</li> <li>• Applications for situational awareness and planning</li> <li>• Common multinational technical terminology</li> <li>• Multinational document sharing</li> </ul> | <ul style="list-style-type: none"> <li>• Experience with multinational cooperation</li> <li>• Relationships with coalition partners</li> <li>• Confidence in the information exchange with coalition partners</li> </ul> | <ul style="list-style-type: none"> <li>• Knowledge of coalition partners</li> <li>• Exchange of personnel</li> <li>• Accommodation of differences</li> </ul> | <ul style="list-style-type: none"> <li>• Policies</li> <li>• Directives</li> <li>• Procedures</li> <li>• Practices</li> </ul> |              |

# Example of T3 factors (questions)

## Technical T1 factor

### Personnel access to coalition network:

What percentage of your nation's strategic planning staff have access to a coalition network?

## Human T1 factor

### Experience with multinational operations:

In the last 12 months, has your nation's strategic planning HQ engaged in multinational collective training/exercises/operations involving coalition partners?

## Organizational T1 factor

### Knowledge of coalition command structures:

Is your nation's strategic planning staff familiar with the command structures of the coalition partners?

## Policy/legal T1 factor

### Policy support of sharing:

Does your nation have policies to allow by default the sharing of information with coalition at the strategic planning level?

# Vet interoperability factors to according to scope (example)

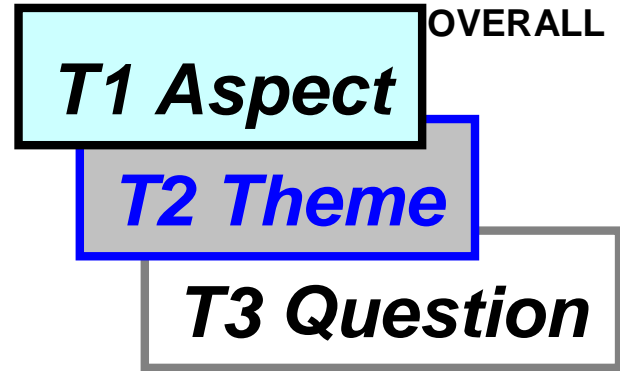
- Technical interoperability can encompass many factors:
  - Openness of architectures
  - Standardization of interfaces and data models
  - Maturity of enterprise architecture
  - Level of standards support by applications
  - Timeliness of information exchanges
- Requires assumptions about how these factors impact operations

# Vet interoperability factors to according to scope (example)

- Operational staff's perspective
  - Black box around interacting technical systems
  - Focus on end effects as experienced by operator
- Completeness and fidelity of information exchange
- Proper handling by the receiving application
- Degree of human intervention required
- Reliability (uptime)



# Replicate hierarchy across nations



*Fictitious data*

- 1 column per nation

# Nations with multiple regional commands

A nation column is determined by its subordinate columns

*Fictitious data*

| Interoperability factor                    | Overall | N1 | N2 | n2.1 | n2.2 | N3 | N4 | N5 | n5.1 | n5.2 | n5.3 | n5.4 | n5.5 | n5.6 | n5.7 | n5.8 |
|--|---------|----|----|------|------|----|----|----|------|------|------|------|------|------|------|------|
| <b>Technical Aspect</b>                    | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ●    | ●    | ●    | ●    | ●    |
| International connectivity                 | ●       | ●  | ●  | ●    | ●    | ●  | ✓  | ●  | ✓    | ●    | ●    | ●    | ●    | ●    | ✓    | ●    |
| Multinational services                     | ●       | ●  | ●  | ✓    | ●    | ●  | ●  | ●  | ✓    | ●    | ●    | ✓    | ●    | ●    | ●    | ●    |
| Applications for situational awareness     | ●       | ✓  | ●  | ●    | ✓    | ✓  | ●  | ●  | ●    | ●    | ✓    | ✓    | ●    | ●    | ●    | ●    |
| Common multinational technical terminology | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ●    | ●    | ●    | ●    | ✓    |
| Multinational document sharing             | ●       | ●  | ✓  | ✓    | ✓    | ✓  | ●  | ●  | ✓    | ●    | ●    | ●    | ●    | ●    | ✓    | ✓    |
| <b>Human Aspect</b>                        | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ●    | ●    | ●    | ●    | ●    |
| Experience with multinational cooperation  | ●       | ●  | ●  | ●    | ●    | ●  | ✓  | ●  | ●    | ●    | ●    | ●    | ✓    | ●    | ✓    | ●    |
| Relationships with other 5-Eyes nations    | ●       | ✓  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ✓    | ●    | ●    | ●    | ✓    | ●    | ●    |
| Confidence in the information exchange     | ●       | ●  | ●  | ●    | ●    | ✓  | ●  | ●  | ●    | ●    | ●    | ●    | ✓    | ✓    | ●    | ✓    |
| <b>Organizational Aspect</b>               | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ●    | ●    | ●    | ●    | ●    |
| Knowledge of other 5-Eyes nations          | ●       | ✓  | ●  | ●    | ✓    | ✓  | ●  | ●  | ✓    | ●    | ✓    | ●    | ●    | ●    | ●    | ●    |
| Exchange of personnel                      | ●       | ✓  | ●  | ●    | ●    | ✓  | ●  | ●  | ●    | ✓    | ●    | ✓    | ●    | ●    | ✓    | ●    |
| Accommodation of differences               | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ✓    | ●    | ●    | ●    | ●    | ●    | ✓    | ●    |
| <b>Policy/Legal Aspect</b>                 | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ●    | ●    | ●    | ●    | ●    |
| Policies                                   | ●       | ●  | ●  | ●    | ●    | ✓  | ●  | ●  | ●    | ✓    | ●    | ●    | ●    | ●    | ●    | ●    |
| Directives                                 | ●       | ●  | ●  | ●    | ✓    | ●  | ✓  | ●  | ✓    | ●    | ●    | ●    | ✓    | ●    | ●    | ✓    |
| Procedures                                 | ●       | ✓  | ✓  | ✓    | ✓    | ●  | ●  | ●  | ✓    | ✓    | ✓    | ●    | ✓    | ●    | ●    | ✓    |
| Practices                                  | ●       | ●  | ●  | ●    | ●    | ●  | ●  | ●  | ●    | ●    | ●    | ✓    | ●    | ●    | ●    | ●    |

# Quantification & rollup of interoperability factors

## 4 kinds of rollup in the framework

- Some questions that ask for a *suite* of answers
  - ➔ Roll up into 1 stoplight result per question
- For each interoperability factor in the hierarchy, **aggregate stoplights for child factors**
- For **each nation**, aggregate corresponding stoplights **across constituent commands**
- **Pan-coalition** stoplight: Aggregate corresponding stoplights **across nations**

# Rolling up complex questions

- Generally roll up row-wise
- If more than 1 row (i.e. table):
  - Roll up rows
  - Roll up resulting column
- 1 stoplight per question per questionnaire return

How interoperable are the following applications in coalition operations at the strategic planning level?

Answer for each partner nation and each application:

- A) Using common applications, or as seamless
- B) Exchanging information with automated assistance in conversion
- C) Manual interpretation & migration of data
- D) Completely not interoperable
- E) Not applicable (choose this for your nation only)

**Increasing interoperability**

| Application   | Nation |    |    |    |    |
|---|--------|----|----|----|----|
|   | N1     | N2 | N3 | N4 | N5 |
| Applications for common operating pictures (including | E      | E  | C  | C  | C  |
| Targeting systems                                     | C      | E  | C  | C  | C  |
| Air battle management systems                         | C      | E  | C  | C  | B  |
| Command and control systems                           | C      | E  | C  | C  | C  |

*Fictitious data*

# Choosing a rollup method

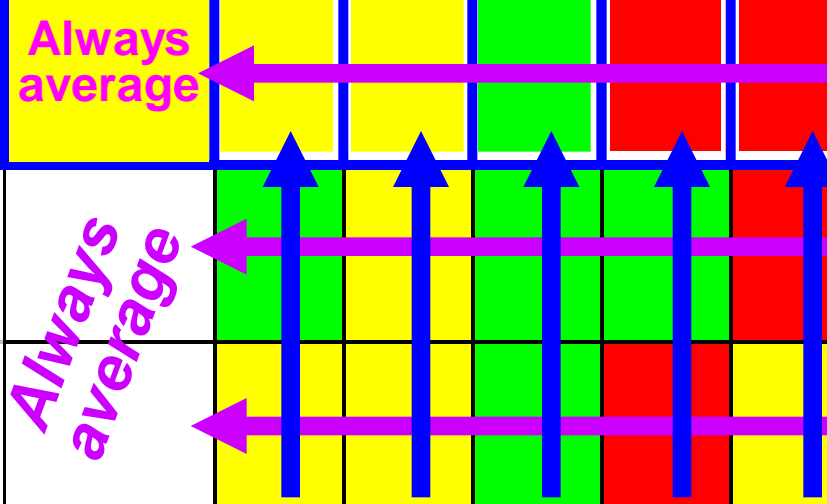
- Emphasis: **Simple** rollup schemes
- Complicated schemes discussed
  - Hard to get **subject matter expertise** to tailor & justify
  - Expect hard to get **coalition consensus** on
- Two rollups used:
  - Take average
  - Take result representing greatest risk to interoperability (“reddest”)
- More suitable methods incorporated with subject matter expertise & consensus across coalition

# Tier 3 & pan-coalition rollups

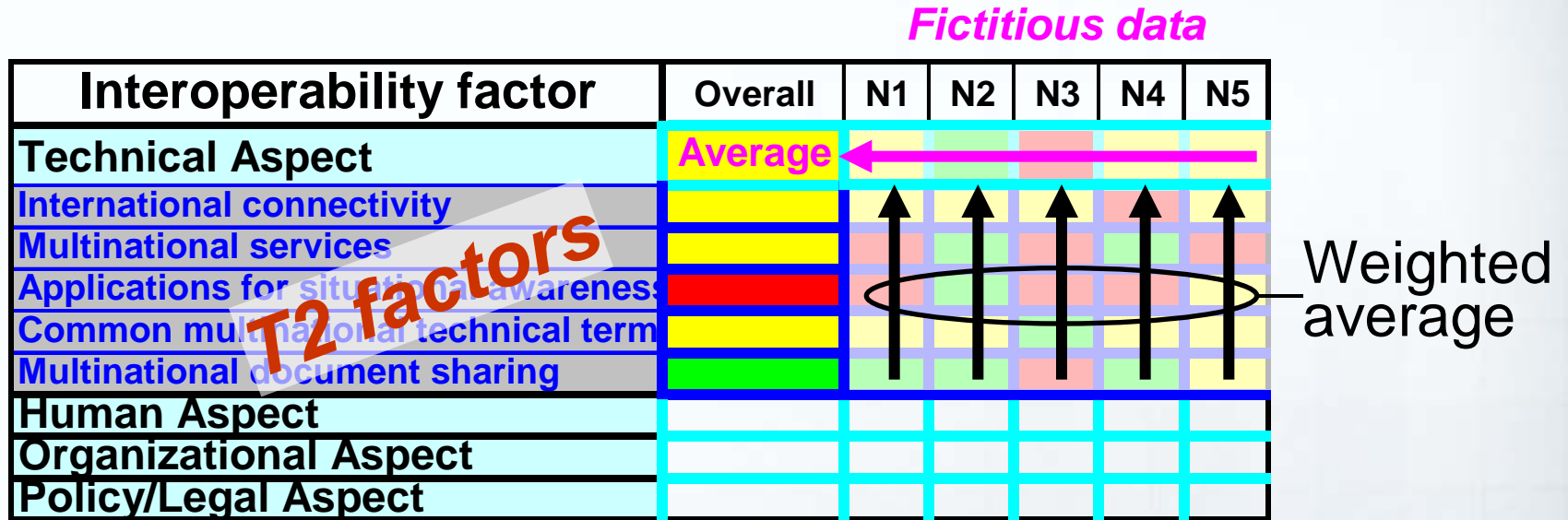
*Fictitious data*

| Interoperability factor |   | Overall        | N1 | N2 | N3 | N4 | N5 |
|-------------------------|---|----------------|----|----|----|----|----|
| -                       | <b>Technical T1 factor</b>  |                |    |    |    |    |    |
| +                       | International connectivity  |                |    |    |    |    |    |
| +                       | Multinational services  |                |    |    |    |    |    |
| -                       | Applications for situational awareness and planning   | Always average |    |    |    |    |    |
|                         | 6 How interoperable are the following applications in 5-Eyes operations at the strategic planning level?  | Always average |    |    |    |    |    |
|                         | 7 What percentage of the time do the following applications properly interoperate between 5-Eyes nations? | Always average |    |    |    |    |    |
| +                       | Common multinational technical terminology  |                |    |    |    |    |    |
| +                       | Multinational document sharing  |                |    |    |    |    |    |
| +                       | <b>Human T1 factor</b>  |                |    |    |    |    |    |
| +                       | <b>Organizational T1 factor</b>   |                |    |    |    |    |    |
| +                       | <b>Policy/Legal T1 factor</b>   |                |    |    |    |    |    |

**T3 factors**



# Tier 2 and tier 1 rollups



- High level, broad interoperability factors
- Weights from ranking of T2 factors in questionnaire



# Rolling up multiple commands / nation

- Egalitarian aim of framework
  - Equal influence from coalition nations
  - 1 representative dashboard column / nation
- Roll up across multiple commands / nation
  - Averaging corresponding stoplights (T1, T2, T3)
- Complication: **Regional** commands might deal with small subset of coalition nations
  - Some questions ask about interactions with *each* coalition nation
  - Some ask about *the number* of coalition nations that one interacts with

# Analysis

- Dashboard patterns indicate likely areas of interoperability “health”
  - Stoplights at high hierarchical levels guide examination of lower levels and descent into questionnaire data
- Follow-on inquiry with respondent nations may be needed for complete understanding of the state of interoperability & underlying causes
- Dashboard also serves as a summary story/illustration of the understanding from iterative deep dives and follow-on inquiries
- Analysis could also lead to revisions of interoperability factors, hierarchical organization, design of questions, quantification and rollup schemes

# Summary

- Framework for characterizing & investigating coalition C4 interoperability and tracking progress
- Scope: Strategic/operational C4 planning external to theatre, operationally focused
- Taxonomy of diverse interoperability factors from multiple sources, quantification and rollup schemes
- Upgradable in piece-wise fashion as subject matter expertise and coalition consensus is obtained
- Visualization dashboard to structure & guide analysis/inquiry and summarize/illustrate findings

# Questions?

# Backup slides

# Future work

- Web questionnaire for mass fielding to operational personnel
  - Synthesize Tier 3 quantifications from many returns per command
  - Minimize guestimates from (and imposition on) lead persons
  - Sharpen questions based on feedback
- Better depiction of input data completeness for stoplights
- Other analyses based on questionnaire data
  - 360° feedback instead of self-reported answers*
  - Asymmetries/disparities between nations*
  - Social network graphs of coalition*
- Expand framework for more diverse coalition
  - More emphasis on language, culture, understanding of command styles

**DEFENCE**



**DÉFENSE**